Student Resource: History and Mechanics of the Trebuchet

◆ History of the Trebuchet

Source: Nasaexplores lesson found at - www.thehurl.org/tiki-download_file.php?fileId=46

A trebuchet is a type of catapult that was used during the Middle Ages to launch projectiles during battle. Trebuchets can be distinguished from other types of catapults in that they do not use stored tension (such as in twisted ropes or flexed wood) to launch objects. Projectiles launched by trebuchets included rocks for smashing through castle walls, venomous snakes, beehives, and even dead animals to spread disease. Since trebuchets required aiming, they were typically used to hit stationary targets such as buildings, walls, and even other trebuchets. A trebuchet has much better accuracy than other types of catapults. Trebuchets were effective during battle because they could be set up a safe distance away from a castle, and the archers guarding it, while still causing significant amounts of damage. Many castles also had trebuchets inside their walls to launch projectiles at their enemies. Since trebuchets had the ability to launch objects very far into the air they could do so from behind castle walls without being seen. A sturdy trebuchet could launch a projectile weighing 300 pounds over 300 yards!

During the Second Punic War in 213 BC Archimedes developed several powerful, accurate catapults to defend Syracuse against the Romans. According to legend, he also developed a trebuchet-like war-machine known as the Archimedes Claw. Although the exact design is not know, it is believed that the claw was a large trebuchet-like or crane-like machine that dropped a hook or anchor onto enemy ships from above, either capsizing or sinking them.

Early forms of the trebuchet were observed in China as early as 4 BC and in Europe in 6 BC. Once gunpowder was invented, the trebuchet became obsolete somewhere around the 16th Century.

◆ What are the parts of the Trebuchet?

There are two basic types of trebuchets: a traction trebuchet and a counterweight trebuchet. Both the traction trebuchet and the counterweight trebuchet consist of a base, an arm and a sling. The base of the trebuchet is what provides the support to the device. Oftentimes, the base of the trebuchet is on wheels for mobility. The arm of the trebuchet is essentially a long beam on a pivot that acts as a lever to fling the projectile. A sling holds the projectile in place at the long end of the arm (farther away from the pivot). The sling could be a pouch that holds the projectile in place. The sling could also consist of a rope which is attached to the projectile and then loosely tied to a release pin at the end of the arm. The rope is designed to slide off the release pin when the arm swings around. In a counterweight trebuchet, a counterweight is attached to the short end of the arm, closer to the pivot. The traction trebuchet on the other hand relies on people pulling down on the short end of the arm with ropes.

Student Resource: History and Mechanics of the Trebuchet (continued)

Here are some science concepts to keep in mind when you are designing and testing your trebuchets.

◆**Levers**
In addition to his numerous accomplishments, Archimedes is considered to be the first person to explain the principles behind levers. Based on his findings he was quoted saying "Give me a place to stand, and I will move the Earth." Levers are one of the six types of simple machines. A lever is a rigid object that is used with a fulcrum or pivot point to increase the amount of mechanical force applied to an object. A trebuchet is considered a class 1 lever. In a class 1 lever the force is applied to one end of the arm, the load on the other end, and a pivot point or fulcrum is in the middle. A playground see-saw is also a class 1 lever.

In a trebuchet the force (counterweight) is much greater than the load (projectile). The fulcrum or pivot point on a trebuchet is not directly in the middle as it is in a see-saw. Here, the pivot point is closer to the counterweight, or the end where the force is being applied.

Mechanical advantage is the factor by which the force or torque put into a mechanism is multiplied. We can calculate the mechanical advantage of any simple machine by dividing the output force by the input force. Another way to calculate the mechanical advantage of a lever is by dividing the length of the effort arm (distance between the fulcrum and the force) by the length of the resistance arm (distance between the fulcrum and the load or projectile).

$$MA = \frac{\text{Output force (at load)}}{\text{Input force (applied)}} \qquad MA_{lever} = \frac{\text{Length of Effort Arm}}{\text{Length of Resistance Arm}}$$

Work is how much energy is transferred by a force acting over a distance. The formula for work is W = F x D. The greater the mechanical advantage the less force required, but it must be applied over a greater distance. The amount of work does not change.